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PING-PONG BALLS AND PRIMARY LITERATURE IN THE CLASSROOM: THE INTERSECTION OF STUDENT ENGAGEMENT AND FACULTY DEVELOPMENT

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I have found student presentations and primary literature to be a lethal combination. I am certain others are familiar with the pain of watching a student stumble through an article while the rest of the class feigns interest. My experience has been that the greatest benefit of student presentations of journal articles has been only to the presenter. The presenter, who puts in the effort to produce a strong presentation, becomes the “expert” in the room, but unfortunately, once the presentation is done, he too joins the ranks of the pained audience. Yet, like Kevin Brown, who in the Fall 2010 issue of *Teacher-Scholar*, encourages his readers to include primary literature in their classes in order to “keep up with the scholarship” (p. 67), I am convinced that the inclusion of primary literature, if done successfully, not only benefits faculty development, but also engages and better prepares the student.

What follows is the current format of my course designed for senior-level undergraduate/entry-level graduate students majoring in Biomolecular Sciences. The course is based on a particular theme that is divided into units. For example, the current version of the course focuses on Signaling in Development with units on Sonic Hedgehog, Notch, Wnt, and BMP signaling pathways. Signaling pathways in early development is also the focus of my research laboratory. I formerly designed the course using a textbook supplemented with a few articles from top-tier science journals. I have since moved to a completely journal article-based structure for this course in an effort to best equip my students with current findings and techniques, as most textbooks focus on foundational information or broad summaries on current topics in the field. Few textbooks go into sufficient detail to allow for in-depth studies or an examination of current protocols within a particular field. Typically, I only select articles published within the last twelve months, with the exception of an occasional review article that may be used for foundational information. The use of top-tier journals ensures that the topics of the articles are cutting edge, enabling me to remain current in the field and helping my students to compete against students graduating from research I institutions for top jobs or advanced degrees within the field of science.

Clustering Articles into Units

Anyone who has read a science journal can attest to the difficulty in comprehending the material. The pages are filled with acronyms, non-standard words, and specific nomenclature that combine to create what my students call “alphabet soup.” The first attempt at reading a science article can take a student several hours, certainly much longer than reading a traditional textbook that has been crafted for easier reading. I have found that defining my course into distinct units (four appears to be the magic number) helps students gain a deeper comprehension of the material. Each unit defines a particular topic or area and begins with a review article to establish the foundation, followed by several full length research based articles. Students have found that the reading becomes easier within each unit as they start to see the same concepts and terms repeated. The students can then focus more on the techniques and protocols outlined in the articles to enhance their understanding of the methodologies. The clustering of articles into units provides a framework whereby students can draw comparisons between different approaches and a means to integrate the material into the “bigger picture.” In addition, it provides me with the opportunity to condense and summarize the units for use in lower level classes or as background information for my creative activity/scholarship.

Increasing Student Engagement

To avoid the problem of feigned interest to student presentations, I have devised a system that encourages the students to read the articles and participate in the discussion. I use a bucket of ping pong balls, each bearing the name of a student in the class. I draw a student’s name from the bucket and ask a question related to the paper or ask the student to explain a particular figure from the paper. If the student answers correctly or at least demonstrates some level of understanding and effort, then the student receives one point. If the student cannot answer or answers incorrectly, then the student loses a point. At this point, other students in the class can volunteer to answer the question and “steal” the point. Once the question has been answered, all of the ping pong balls are returned to the bucket. This creates a situation where the students are never off the hook. A student’s ping pong ball can be pulled multiple times during a class or not at all. At the end of the semester I analyzed the number of times a student’s ping pong ball was drawn. The results suggested that for a class of 38 students, the drawing of ping pong balls was completely random and that each student’s ping pong ball was drawn roughly the same number of times during the semester. The total points earned for participation accounted for 55% of the final grade.

Assessing Student Comprehension

In addition to the point system described above, the course also includes several heavily weighted written assignments and in-class group activities. These provide additional opportunities for students to demonstrate their comprehension of the material, especially for those who are uncomfortable with speaking in class, or who may require more time to synthesize the information. The assignments ask the students to expand on the material in the articles. For example, some of the assignments ask the students to propose and design the next set of experiments (future directions) that would advance the particular topic being discussed, and to provide the rationale for their experiments. This forces the students to examine carefully the articles read for class and to piece together the results from several articles into one comprehensive picture that is then used to support their rationale for the proposed future direction. Other assignments ask the students to compare and contrast the results presented in the various papers used for the unit. These prove interesting as some of the conclusions in one paper are in direct contradiction with conclusions in another paper. The students need to decide and discuss which results are better supported and why. In addition, the students are asked to propose how the contradiction could be resolved. Once again, this provides students with the opportunity to demonstrate their level of comprehension of the material.

Outcomes

Initially, the use of the ping pong balls created much anxiety for the students. Several students complained that the system was unfair as their name could be pulled on a day when they had not fully read or comprehended a particular article. I replied that their name could be called on a day when they had fully read and comprehended the article or that they could be asked one of the easier questions. Essentially, the use of the ping pong balls randomized the class participation, holding students accountable for each article and any questions that could be raised.

The expected outcome for the use of the ping pong balls was greater preparedness of the student prior to class, which proved to be the case. The other result from using the ping pong balls and the above mentioned point system was completely unexpected. A healthy competition for who could steal the most points developed between the students. Students self-assembled into study groups, which met prior to class, to discuss the articles. More study groups formed as the competition heated, and the intensity at which the students examined the articles also increased. A side effect of these study groups was a greater level of in-depth comprehension, which made for very effective class discussions. Furthermore, a desire of not wanting to be left out developed among the students resulting in a

vast majority of the students coming to class fully prepared and being completely engaged in the class discussion. It also resulted in a marked increase in the quality of the written and in-class group assignments.

My experience has been that there are always different populations of students in any class, students who want to be engaged and learn as much as possible, and those who sink low in their seats hoping to avoid being called on, and who aim to do the minimum required for the course. This was not the case with this course. I have taught many journal-based courses at this level in the past, but to date, none has compared with this course in terms of student engagement and comprehension; or has been as enjoyable for me as the instructor. The majority of the students did well in this course, earning final grades of B or better. Typically grades in my journal-based courses were in the C to B range with a class average of 81. This was quite an accomplishment for the students as the nature of the course and the outcomes described above allowed me to be more demanding than I have been in previous courses. As the student's engagement and comprehension increased, my expectations also increased resulting in the most in-depth and demanding course that I have taught, but with the highest level of student success and satisfaction. Responses on student opinion surveys that were administered at the end of the semester revealed that the majority (36 of 38) preferred the new class format over the traditional lecture-style format. Students responded that the format and use of the ping pong balls forced them to read the articles and to keep them engaged in the course. Many commented that they felt the format provided a more interactive environment for learning and that it allowed for the student to play a more active role in the "teaching" of the material. They also responded that they had learned more in this course than in other courses, and that they would like to take more courses with this format. My colleagues note that students who have completed my course are significantly more proficient at approaching and analyzing the primary literature than students who have not taken my course.

The outcomes for me as the instructor for the course were twofold. The material selected for the course served to enhance my teaching and to advance my understanding of the current state of my field and area of creative/scholarship activity. In addition, the course provided the means to improve my teaching and assessment strategies, a critical component for a faculty member at a SCU. The format of this course and the various exercises will be added to my arsenal of teaching material and will be adapted for use in several of my courses, which extend from 100-level to graduate level courses. Furthermore, I found the student engagement in this course invigorating, thus providing me with one of the most enjoyable teaching experiences I have had in my 15 years of teaching.

Finally I would like to conclude this section by describing one of the highlights from this course that also served as the basis for the title

of this essay. One of the students in the course was also a member of my research laboratory (students in our program are required to complete a minimum of two semesters of independent research). This student made a connection between one of the articles in the course with the research currently being done in my laboratory. The connection was not completely obvious, but stemmed from the student's comprehension of the course material and his understanding of the current research direction of my laboratory. The student and I have already completed preliminary experiments to examine this connection and now this has become a new direction for exploration in the laboratory, thus furthering my own creative activity and providing additional opportunities for student-based research projects. As a faculty member whose primary responsibility is teaching, there is no finer or more enjoyable moment than witnessing a student's intellectual growth. The example just described illustrates how just one article from the course was at the intersection of student engagement and faculty development.

Future Directions

The demands on faculty at State Comprehensive Universities to be both excellent teachers and scholars require that faculty use their time efficiently and strategically to meet these demands. Central Connecticut State University faculty, as at most SCUs, teach twelve credits each semester as well as fulfill service and professional duties, leaving little time to devote to scholarship. Remaining current in one's field is a challenge, especially for faculty in the natural sciences, such as mine, Biomolecular Sciences, where advances occur rapidly with scientific advances published almost daily in academic journals. The course outlined above, which conceivably could be adapted to almost any discipline, is one suggestion to meet that demand. The time spent preparing for the course benefits the students with current content and techniques, and the instructor with material that can be applied toward scholarship activities. In addition it provides a learning opportunity that is engaging both to the students and the instructor.

The use of primary literature in the classroom is a growing area of research within science education. Most recently in the *Journal of College Science Teaching*, Wenk and Tronsky present their findings on the benefits of including primary literature as part of the first year experience (Wenk and Tronsky, 2011). The authors present compelling evidence that first year students can critically evaluate primary literature. Although the students in this study demonstrated improvement in their understanding of the hypothesis, design setup and results, the authors note that the students did not improve in their ability to propose alternative explanations or future research experiments. Students in my course were proficient at these skills as demonstrated through graded written assignments. One

possible approach to including primary literature within the curriculum could combine including primary literature in the first year experience followed by an upper level course as described above. Such an approach would close the loop on including primary literature in the classroom.

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